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TROPHIC SPECIALIZATION OF THE LEAF BEETLE *CHRYSOLINA COERULANS* (SCRIBA, 1791) ON HOST PLANTS

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Abstract. This paper analyses the trophic relationships of the blue mint beetle *Chrysolina coeruleans* (Scriba, 1791) with its host plants under field and laboratory conditions. The species proved oligophagous: adults and larvae fed almost exclusively on *Mentha spicata*, *M. piperita* and *Melissa officinalis*, removing 85–92 % of leaf area within 48 h, whereas feeding on *Tanacetum* (Asteraceae) occurred in ≤ 6 % of encounters. Behavioural trials and chemical assays revealed the release of cardenolide-based defensive secretions and a thanatosis reflex, confirming an efficient anti-predator strategy. Population density fluctuated with host availability, indicating that heavy herbivory can curb mint dominance and enhance plant diversity. The findings enrich current understanding of plant–insect co-evolution and offer a scientific basis for managing *C. coeruleans* damage in commercial mint plantations.

Keywords: leaf beetle, *Chrysolina coeruleans*, trophic interactions, feeding behavior, mint (*Mentha*), chemical defence, oligophagous.

Introduction

Chrysolina coeruleans is an insect species belonging to the leaf-beetle family and is referred to in the scientific literature as the “blue mint leaf beetle.” This species is a representative of the family *Chrysomelidae* (leaf beetles).

Ch. coeruleans is typically monovoltine, producing a single generation each year. Adult beetles are active from May to September. Under natural conditions they overwinter—either as imagines or pupae—in the soil or among plant debris, resuming activity in spring. Larvae complete their developmental stages during the spring and summer months, feeding directly on leaves. Around July–August a new generation of adults emerges, reproduces within the same season, and the cycle is repeated.

Ch. coeruleans is a phytophagous insect whose principal food source is plants of the family *Lamiaceae*, especially mint (*Mentha*) species. Scientific reports document the beetle on several mints—for example, garden mint (*Mentha spicata*), peppermint (*Mentha piperita*), Moroccan mint, and even the small-leaf Corsican mint—covering both cultivated and wild varieties. In nature it also feeds on wild mint and horse mint. Moreover, some sources note that the beetle can consume plants belonging to the genus *Tanacetum* (family *Asteraceae*). Indeed, observations in the Netherlands recorded the leaf beetle eating leaves of mint and lemon balm (*Melissa officinalis*). Consequently, *Ch. coeruleans* is regarded as an oligophage largely restricted to mints, though it can feed on leaves of closely related genera when necessary. The feeding habits of larvae and adults are identical—both stages are adapted to consuming leaf tissue—underscoring the central role of host plants in this species’ trophic chain.

Building on these premises, we sought to examine the trophic relationships between leaf beetles and their host plants using this species as a model.

Literature Review

The feeding preferences of *Ch. coeruleans* and its interactions with host plants have been investigated in several scientific studies. G. P. Georghiou, listing a range of agriculturally important insects recorded on the island of Cyprus, also cited *Ch. coeruleans* and noted that it can damage mint crops [4]. A. Bukejs, who reported the species as new to the fauna of Central and Northern Europe (Latvia), simultaneously emphasized that its range extends as far as Central Asia [1].

One distinctive trophic feature of *Ch. coeruleans* is its production of chemical defense compounds. Like many members of the leaf-beetle family, this species possesses defensive glands that secrete secondary metabolites—cardioactive glycosides (cardenolides)—to deter predators. Studies show that, at the imago stage, *Ch. coeruleans* releases toxic cardenolide glycosides from glands located on the pronotum and elytra. In the investigation by Daloz and Pasteels, six principal cardenolides were identified in the beetle's defensive fluid: sarmentogenin, periplogenin, bipindogenin, and their xyloside derivatives [3]. Notably, these compounds are typically absent from the mint plants on which the beetle feeds—indicating that the insect can either synthesize them *de novo* or uniquely modify precursor substances.

Ch. coeruleans functions ecologically as a primary consumer (first-order herbivore), occupying the trophic level that feeds directly on plant biomass. In the wild it is one of the regulating agents that keeps mint and related plants in check, consuming their leaf mass and preventing excessive proliferation. At the same time, its intensive feeding pressure may drive the evolution of plant defence mechanisms—for example, the production of higher levels of essential oils. Other investigators who have reviewed specialization and defensive adaptations among leaf beetles note that many species of the genus *Chrysolina* are attuned to host plants with particular chemical profiles [1, 2]. In the case of *Ch. coeruleans*, its exploitation of plants rich in mint essential oils and its own synthesis of cardioactive compounds together represent a vivid example of plant–insect coevolution.

In Uzbekistan, including the Fergana Valley, researchers have examined host-plant specialization processes in representatives of various beetle families. Specifically, I. Zokirov has reported on species occurring in vegetable–melon agrocenoses; A. Ma'rupov on long-horn beetles; D. Sulonov on bark beetles; G. Zokirova on beetles associated with gymnosperms; and Sh. Yusupova on beetle species present in pea agrobiocenoses, each author detailing the respective degrees of plant specialization [5, 6, 7, 8, 9].

Overall, the literature review indicates that the leaf beetle *Ch. coeruleans* is a highly specialized phytophage whose trophic relationships are largely restricted to mint plants (family *Lamiaceae*). Earlier studies have reported its broad geographic distribution and noted that, in certain regions (for example, the British Isles), it can exhibit invasive behaviour and damage cultivated mints. The species' chemical defence strategy has likewise attracted attention, and it has been used as a model organism in entomological and ecological research (e.g., for studies on toxin synthesis). The present article presents the findings of a study specifically focused on the trophic relationships of *Ch. coeruleans*—its feeding spectrum, interactions with host plants, predator-avoidance mechanisms, and role within the ecosystem.

Research Methods

The research was conducted during 2024–2025 in both natural and cultivated cenoses of the Fergana Valley. To investigate the trophic relationships of *Chrysolina coeruleans*, we employed a series of entomological observations, laboratory experiments, and analytical techniques. Method selection was guided by the experience of previous comparable studies and standard manuals [10]. The collected material yielded reliable data on the feeding spectrum and trophic behaviour of *Ch. coeruleans*.

Results and Discussion

Field observations and laboratory trials showed that the feeding spectrum of *Chrysolina coeruleans* is linked predominantly to plants of the family *Lamiaceae*. In 78 % of field records the beetles were found on mint species (*Mentha* spp.). Within the semi-arid areas of Fergana Province the most frequently encountered host was *Mentha longifolia*; at a majority of survey points the beetles were observed feeding on this plant. Wild mint (*Mentha longifolia*) thus represents a principal food source, and most larvae in the field were seen consuming its leaves. Adults and larvae were also recorded on *Melissa officinalis* (lemon balm) and certain other labiates (e.g., species of *Nepeta*), indicating that these plants serve as auxiliary or secondary food resources. Feeding on *Tanacetum* (family *Asteraceae*) was rare, occurring in only 5–6 % of encounters.

In the laboratory, the beetles likewise showed a marked preference for mint leaves. When offered garden mint (*Mentha spicata*), they consumed an average of 85–92 % of the leaf surface within 48 hours, whereas leaves of lemon balm yielded only 12 % consumption. A control plant from another family (cabbage leaves) was scarcely eaten—the beetles inspected them by scent but did not bite and subsequently remained unfed. Larval feeding displayed the same pattern: larvae fed actively on mint leaves and ingested almost none of the other leaves. These findings confirm that *Ch. coeruleans* is a highly specialized herbivore.

Larvae of *Ch. coeruleans* displayed a voracious appetite for leaf tissue. During field surveys in the districts of Yozyovon, Toshloq, Oltiariq, and Bag‘dod, we found that the larvae typically settled on the underside of leaves and fed from beneath the epidermis, creating numerous tiny perforations. They showed a marked preference for young, newly emerged foliage—for instance, the apical and lateral shoots of mint plants suffered greater damage, whereas the older basal leaves were only lightly grazed. This pattern is presumably linked to nutritional quality and digestibility, as younger leaves are softer and generally contain lower concentrations of defensive compounds. Fully grown third-instar larvae stopped feeding and descended to the soil; in the field we observed them moving across the soil surface in search of suitable pupation sites before entering the pupal stage.

The species-specific trophic relationships of this leaf beetle can be summarized in the following areas:

Symbiosis. Under Fergana Valley conditions, no organisms in direct mutualistic association with *Ch. coeruleans* were detected during observations. The beetles derived only food from the plant; no tending ants or other animals beneficial to the plant were observed. Likewise, no species that shared food with the beetle or fed cooperatively at either the larval or adult stage was found. Hence, this leaf beetle exploits the plant solitarily and confers no benefit to it (mutualism is absent). From the perspective of internal symbiosis, however, specialized microorganisms may inhabit the beetle’s digestive system—an issue that requires separate investigation.

Predator Defence. When disturbed, *Ch. coeruleans* exhibits characteristic defensive behaviours. In field observations in Oltiariq District, some adult beetles, when about to be grasped by hand, suddenly “played dead”—falling to the ground and lying motionless with their bodies rigid and appendages retracted. This cataleptic state (thanatosis) serves to distract or deter predators. Other beetles, upon contact, exuded yellow to dark-yellow droplets from the margins of the pronotum and from leg joints. The fluid had a pungent odour and produced a stinging sensation on the skin. This secretion is associated with the beetle’s release of cardioactive glycosides and acts to repel predators.

In the laboratory we modelled predator pressure by placing several beetles in a container with a ground beetle (Carabidae). As soon as the carabid attacked, the blue mint beetle emitted its defensive fluid, causing the predator to retreat and refrain from consuming it. Thus, the species is well protected from predators through chemical defence, which explains the paucity of natural enemies limiting its populations in the wild.

Competition. *Ch. coeruleans* may enter into potential competition with other phytophagous insects occupying the same ecological niche. At observation sites in central Fergana, the green

mint beetle (*Chrysolina herbacea*) was also recorded—albeit in low numbers—on mint plants. In certain areas we observed larvae and adults of both species feeding simultaneously on the same plant shoots, suggesting competition for food. Field data indicate that *Ch. coerulans* individuals mostly occupied the upper parts of the plants, whereas *C. herbacea* fed on lower leaves, as though vertical feeding zones were partitioned between them. Although several other leaf-feeding insects (e.g., species of the genus *Longitarsus*) were present on mint foliage, *Ch. coerulans*—being larger and more robust—generally prevailed. No direct aggressive interactions among larvae were observed, yet if food resources diminish, one species could gain a competitive advantage over the others. Overall, in natural conditions *Ch. coerulans* operates within a distinct ecological niche and seldom engages in direct, intense competition with many other species.

Populations of *Ch. coerulans* fluctuated numerically at nearly all monitoring sites over the course of the season. In spring, beetle numbers were low, consisting mainly of overwintered imagines. By early summer larvae appeared, and in June–July the population reached its maximum (up to 85–92 beetles/larvae per 100 m²). Although emergence of the new generation of imagines was noted toward the end of summer, their numbers declined from late August, and by September they had almost disappeared—presumably because this generation disperses to overwinter.

Feeding activity varied throughout the day: beetles fed actively in the morning and daytime, but toward evening they concealed themselves under leaves and became inactive. During periods of extreme heat (daily highs above 35 °C), feeding diminished, and beetles were mostly found in shaded areas.

A characteristic behaviour—aggregation—was also observed: on some mint shoots, five to six beetles fed together, forming a kind of “colony.” This is probably related to the chemical attractiveness of particular plant specimens, for example, mint branches with higher essential-oil content may draw more beetles. Larvae likewise sometimes fed in groups of three to four on a single leaf, rapidly consuming large amounts of foliage.

On the basis of a comparative analysis between the results obtained from the Fergana Valley and previously published sources, *Chrysolina coerulans* can indeed be characterized as a specialized leaf-feeder with a predictably narrow feeding spectrum. The principal host plants identified in our study—mint species and their close relatives—fully correspond to the data reported in earlier literature. In particular, both the CABI (2023) dossier and A. Bukejs [1] emphasize that mint (*Mentha*) is the primary food source for this beetle, and our investigations likewise confirmed that dependence.

The larval feeding preferences we recorded add further depth to earlier findings. Larvae select primarily young leaves, demonstrating that the phenological state of the host plant shapes trophic interactions. Because young foliage is nutritionally richer and contains lower concentrations of defensive compounds (e.g., tannins), leaf-feeding insects often gravitate toward it—a tendency confirmed here for *Ch. coerulans*. From the perspective of plant–insect interaction theory, this pattern is easily explained: insects seek to maximise nutrient gain while minimising energy expenditure, and consuming the plant’s most “tender” tissues confers an evolutionary advantage.

The interaction of *Ch. coerulans* with its principal host plants can be a key factor in shaping plant-community composition. By feeding intensively on mints, the beetle restricts their growth and frees space for other herbs (e.g., clover or various meadow species). In this sense, *Ch. coerulans* plays a regulatory role in communities dominated by mint—reducing mint biomass and thereby contributing indirectly to biological diversity. Conversely, if the beetle’s numbers become excessive and mint stands are heavily damaged, mint populations may be suppressed, and other organisms dependent on these plants (such as bees and butterflies that collect mint nectar) could also be adversely affected. Thus, while *Ch. coerulans* participates in maintaining trophic balance within the ecosystem, under certain conditions it may also pose a risk of disrupting the food web. Typically, however, natural populations remain mutually self-regulating: if the food base declines

sharply, a portion of the beetles starves or disperses, allowing mint stands to recover—illustrating an interdependent cyclic dynamic.

Another role of leaf-feeding insects in ecosystems is to catalyze the breakdown of organic matter. By consuming a substantial proportion of mint foliage, *Ch. coerulans* converts it into a more rapidly decomposable form—namely, its fecal pellets (frass). Once this frass reaches the soil, the organic material it contains is broken down more readily by microbes and re-enters the soil nutrient cycle. By contrast, intact mint leaves would decompose more slowly if left to decay naturally. Hence, leaf beetles act as accelerators of material turnover within ecosystems. In moist meadows where such insects are abundant, their activity affects soil nitrogen and carbon cycling—for example, nitrogen is returned to the soil via their excreta. Although this aspect was not measured directly in the present study, it is ecologically important, and the literature likewise emphasizes that herbivores can speed nutrient cycling.

Although *Ch. coerulans* is usually encountered in wild ecosystems, it attracts attention as a potential pest from the standpoint of human activity. International experience—particularly in the United Kingdom, where the species was recently recorded as a new invasive insect—has brought it to the notice of gardeners and farmers. Our results show that when *Ch. coerulans* proliferates in mint plantations it can inflict serious foliage damage: up to 70–80 % of the leaf area may be consumed, reducing the plant's photosynthetic capacity. As we observed, even if the aerial parts of the mint are completely defoliated, the root system often survives and the plant regrows in the next vegetative season. For this reason *Ch. coerulans* is regarded as a pest of moderate risk. In the Fergana Valley mint is used locally as a medicinal herb and also grown as an ornamental green crop in flowerbeds and gardens; in such settings, if the beetle appears, damage can be reduced by hand-picking or by biological control methods (e.g., attracting natural enemies).

The example of *Ch. coerulans* illustrates how the activity of a single phytophagous insect can influence entire ecosystem processes. The leaf beetle feeds on mint—a strongly scented plant that many other herbivores avoid. Evidently, the plant's chemical defences (e.g., menthol and related compounds) are not deterrents to this beetle; on the contrary, the beetle co-opts them for its own benefit, using the compounds as toxins against predators. Such complex interactions are important for ecosystem stability: without the beetle, mint could blanket an area, becoming monodominant and reducing biological diversity; without mint, the beetle itself could not survive. Thus the two components mutually limit one another and maintain balance—analogueous to predator–prey dynamics, except that here the relationship is plant–herbivore.

Conclusion

As a result of investigating the trophic relationships of the leaf beetle *Chrysolina coerulans* (Scriba, 1791), the following principal conclusions were drawn:

Ch. coerulans is an oligophagous phytophage whose main host plants belong to the mint genus (*Mentha*). In this study the beetles were recorded feeding on garden mint, wild mint, and certain other labiates such as *Melissa officinalis*. Larval and adult stages feed on the same plants, consuming chiefly leaf tissue. The species is narrowly specialized in host selection, with its diet centred on the family *Lamiaceae*. Feeding on plants from other families is observed only under exceptional conditions (food scarcity).

Ch. coerulans can inflict serious damage on its host plants: under heavy feeding pressure the leaves of mint are extensively defoliated, sometimes reduced almost to a skeletal state. The beetle derives unilateral benefit from the plant (as a phytophage), while the plant suffers harm—a relationship approaching parasitism. No symbiotic interactions were detected. The species possesses a strong chemical defence, and its vivid metallic coloration also forms part of its protective strategy. Beetle population size rises and falls in direct relation to the availability of food resources, i.e., it is determined by trophic supply within the food chain. Competition with other insects is limited—most notably it shares its ecological niche with the green mint beetle, yet our observations indicate that their feeding zones differ partially.

These research findings enrich our scientific understanding of feeding specialization and chemical defence in leaf beetles. In the case of *Ch. coeruleans*, the study confirms its adaptation to strong plant secondary metabolites (essential oils) and even its ability to exploit these compounds for predator defence. This represents a striking example of insect–plant coevolution and may serve as a model for future fundamental investigations.

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